government, until the arrival of George I. from Hanover, appointed Addison their secretary. On the king's arrival, a new ministry was formed, in which Addison was again appointed Chief Secretary for Ireland. In 1715 he relinquished the secretaryship for a seat at the Board of Trade, and returned to London. The most remarkable event in his history at this period was his quarrel with Pope, who accused him of malignant jealousy, because he gave him some advice regarding the "Rape of the Lock" which did not turn out as well-timed as Addison honestly believed it to be. Into the details of the dispute our space will not permit us enter. It is enough to say, that everybody now believes Addison to have been in the right, and Pope in the wrong—the one to have been noble minded, honourable, and well-meaning, the other spiteful, jealous, peevish, and suspicious.

In 1716 he married his old flame, the Countess Dowager of Warwick, who at last accepted him when his position left her no excuse. His official standing was very high, and he had inherited the property of a brother who had died governor of Madras, which enabled him to purchase an estate in Warwickshire. He now took up his abode in Holland House, since become so celebrated for the brilliant réunions which in the early part of the present century took place within its walls, comprising all the talents and all the graces of a glorious intellectual epoch—wit, eloquence, and poesy. Not long after his marriage he was made Secretary of State, by a modification of the ministry. But he did not long enjoy his elevation. Declining health compelled him to resign upon a pension of £1,500 a year. The remainder of his life, except during a silly political quarrel with Steele, carried on in the columns of two periodicals started for the purpose, was passed in calm retirement. Though suffering severely under the attacks of disease, his last moments were characterised by a pious fortitude arising out of the implicit and child-like trust in God which had always distinguished him. He sent for his son-in-law, a wild and dissipated young man, that "he might see how a Christian could die!" On the 17th of June, 1719, he was no more.

His body lay in state in the Jerusalem Chamber, and was borne thence to the Abbey by torch-light, at the dead of night, the choir chanting a funeral hymn. He was interred on the north side of the chapel of Henry the Seventh in the vault of the Albermarle family. It was not until very recently that any monument was erected to his memory in the great temple in which so many famous Englishmen lie sleeping; but the visitor to Westminster Abbey may now see his effigy skilfully sculptured in the Poet's Corner, representing him clad in his dressing-gown, and holding in his hand a roll of paper. "Such a mark of respect," says a great essayist of our own time, "was due to the unsullied statesman, to the accomplished scholar, to the master of pure English eloquence, to the consummate painter of life and manners. It was due, above all, to the great satirist, who alone knew how to use ridicule without abusing it, who, without inflicting a wound, effected a great social reform, and who reconciled wit and virtue, after a long and disastrous separation, during which wit had been led astray by profligacy, and virtue by fanaticism."

PHOTOGRAPHIC SELF-REGISTERING MAGNETIC AND METEOROLOGICAL APPARATUS.

INVENTED BY MR. BROOKE, OF KEPPEL-STREET, LONDON.

The importance of instruments whereby the direction and intensity of the earth's magnetism may be readily ascertained, is acknowledged by all scientific men; and the application of photography to this purpose is a means whereby much labour has been saved in meteorological observations. In the following paper we purpose explaining, as briefly as we can, how these observations are made by self-registering apparatus.

Terrestrial magnetism is a *directive*, not an *attractive* force, exercised by the earth and its surrounding atmosphere upon a compass needle, or a freely suspended bar magnet. That it is not an attractive force, may be readily shown by floating a compass needle by means of a piece of cork on a vessel of water: the needle will be found to take its position in the direction of the magnetic meridian; but it exhibits not the least tendency to float towards the north, although perfectly free to do so if any attractive force were exerted upon it in that direction.

The *magnetic* does not coincide with the *astronomical* meridian, but is variously inclined to it at different points of the earth's surface. The angle at which these two meridians are inclined to each other is the *magnetic declination*. The value of this angle is at the present time about $22\frac{1}{2}°$ in the vicinity of London, and its direction towards the west.

A compass needle is ordinarily supported in such a manner as to rest horizontally in the magnetic meridian; but if it be so sustained as to be capable of moving freely in a vertical plane, the marked end of the needle will point or dip downwards, and the angle which the needle when in its position of rest makes with the horizontal plane is called the dip. The present value of this angle, in the same locality, is about $68\frac{3}{4}°$.

The force by which the marked end of the needle is thus directed obliquely downwards, may be conceived to be compounded of two forces, one acting horizontally and the other vertically; by the former of which, acting alone, the needle would assume a horizontal, and by the latter a vertical position. In the present instance, the proportion of the vertical to the horizontal force is nearly as 2 to 1.

These three elements of terrestrial magnetic force, namely, the declination or direction of the vertical plane in which it is exerted, and the amount of its horizontal and vertical components, are found to be continually in a state of change: some of the variations being of a periodical character, while others, far more irregular and extensive in amount, are of less frequent occurrence, and arise from causes that are at present very imperfectly understood.

The general object of magnetic observations is to obtain a complete knowledge of the physical causes on which the existence of terrestrial magnetism, and its various changes, depend. This knowledge is to be sought by a comparison of the observed changes in the three elements of magnetic force with the occurrence of other natural phenomena. The instruments by which the changes of the magnetic elements are observed are the declinometer, the bifilar or horizontal force magnetometer, and the balanced or vertical force magnetometer. The declinometer consists of a bar magnet freely suspended by a bundle of untwisted silk fibres: the variations of the position of this magnet correspond with those of the vertical plane in which the earth's force is exerted. The bifilar is a similar bar magnet, suspended by two nearly parallel bundles of fibres, separated by a small interval. The double point of suspension is twisted round until the bar assumes a position exactly perpendicular to the magnetic meridian, in which it will then be retained by the opposition of two equal forces—the gravity of the bar and its appendages tending to untwist the suspensive skeins, while the horizontal component of the earth's force tends equally to turn the bar in the opposite direction. As the former of these forces remains constant, it is clear that any variations of the latter will produce corresponding changes in the position of the magnet; and it is by observation of these changes of position that the variations of horizontal magnetic force are determined.

The balanced magnetometer is a bar magnet, very delicately poised on knife edges, so as to move in a vertical plane like the beam of a balance. This instrument is placed at right angles to the magnetic meridian, and is maintained in a horizontal position by a weight, which counteracts the tendency

of the earth's vertical force to place the magnet in a vertical position. As the counterpoise remains constant, it follows that any changes in the amount of vertical force will be indicated by corresponding changes in the position of the magnet; which latter have been made a subject of observation.

The method hitherto adopted for observing the indication of these instruments, has been that of viewing, through a fixed telescope, the divisions of a fixed scale reflected by a plane mirror attached to each magnet. But by this system of observation a very imperfect knowledge of the nature of magnetic changes has been obtained; and as it has been deemed necessary, in magnetic observatories, that the observations of the various instruments should be made at intervals of at furthest two hours, by night as well as by day, this laborious duty has devolved upon the assistants: hence some means of enabling these instruments to record their own changes has long been an acknowledged desideratum in physical science. With the aid of photography, this desired object has been attained by the instruments that form the subject of this notice, the merit of which has been acknowledged by the award of a council medal by the jurors of the Great Exhibition of 1851.

By these instruments, an uninterrupted and unerring record of all magnetic changes is now maintained at the Royal Observatory, Greenwich. These results could not have been obtained by personal observation; for even if every telescope were constantly watched by the eye of an assistant (which would require a very numerous staff), the results would still be liable to errors of observation; and occasionally the magnetic variations are too rapid and transient to be continuously recorded by an observer. We may further remark, that since the employment of this apparatus at Greenwich, the number of assistants in the magnetic department has been reduced, and the fatigue of night duty has been dispensed with entirely.

Magnetic registration is undoubtedly the most useful application hitherto made of the beautiful art of photography. The method suitably applied to each of the magnetic instruments may be thus described:—A concave metallic mirror, three inches in diameter, is attached to each magnet by a frame possessing all requisite adjustments: the rays of light from a lamp or gas-burner, placed at a distance of about two feet from the mirror, pass through a small aperture in a metallic plate, and fall on the mirror, whence they are reflected to a focus at a distance of about nine feet. The source of light being fixed, it is clear that the movements of the focal point of light will correspond with those of the magnet. A cylinder covered with photographic paper is so placed that the point of light may fall on it. The cylinder is carried round on its axis by clock-work, and, by the combined movements of the point of light and of the cylinder, the magnetic curve is self-traced upon the sensitive paper. The photographic process has also been applied to the barometer, and to the wet and dry bulb thermometers; but the mode of application is different from the preceding, the light not being reflected from a mirror. The description of the figures will render further explanation unnecessary.

As the preparation of the sensitive paper used in these instruments differs somewhat from the ordinary photographic processes, it may not be inappropriate to describe it:—The paper is first washed with a solution of four grains of isinglass and of iodide, and twelve of bromide of potassium, in one fluid ounce of distilled water, and dried quickly by the fire; a considerable quantity of paper may be thus prepared at once. Previously to being placed on the cylinder, the paper is washed over with a solution of fifty grains of nitrate of silver to one ounce of water, which communicates to it the requisite degree of sensibility. After having been in action for twenty-four hours, the paper is removed from the cylinder, and the impression developed with a warm solution of twenty grains of gallic acid to one ounce of water, with a small addition of the ordinary commercial strong acetic acid. We may now proceed to explain the working of these very ingenious instruments.

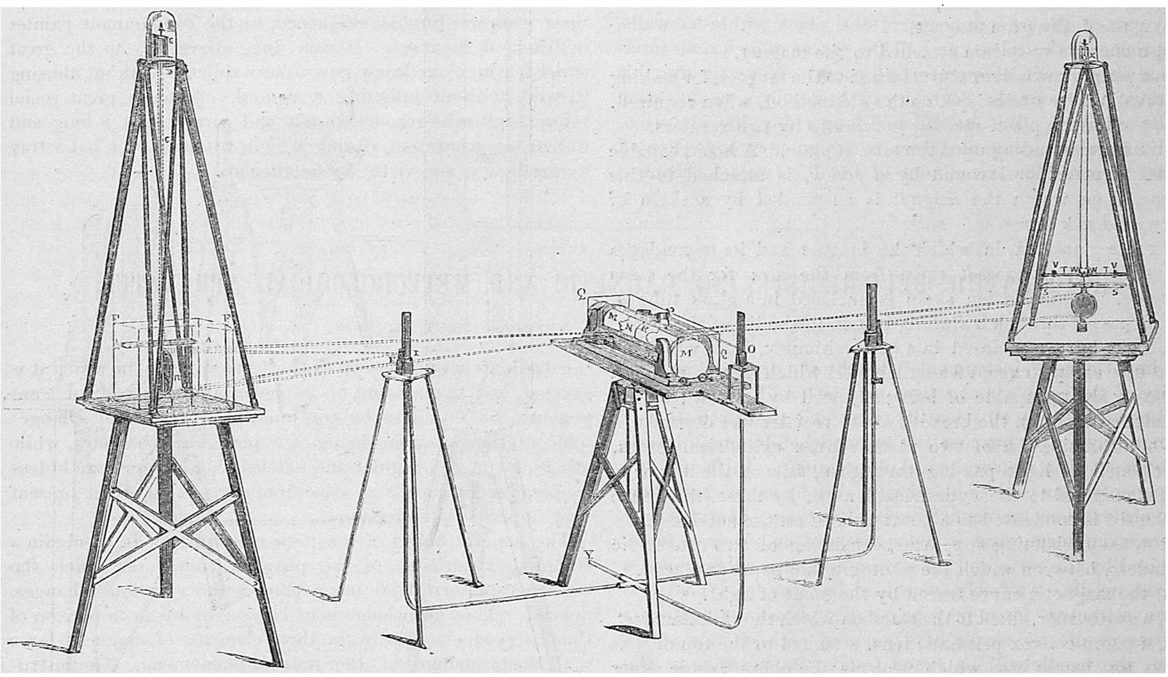

FIG. 1.—BROOKE'S SELF-REGISTERING DECLINOMETER, AND BIFILA MAGNETOMETER.

Fig. 1 represents the principal self-registering apparatus invented by Mr. Brooke. The apparatus is supported by a framework of tubes springing from the four corners of a black-marble slab (which, when in actual operation, would be cemented on the top of a stone pillar firmly fixed in the ground, and insulated from the floor of the observatory): these tubes, about four feet long, converge alternately to four points of the torsion plate; they thus compose a framework possessing great stiffness. To the suspension-frame of each magnet, a plane glass mirror and a concave metallic speculum are attached. The plane mirror is for the purpose of making

eye-observations with a telescope in the usual manner. A gas-light or lamp is so placed, at a distance of about two feet in front of each speculum, that an image of a small slit in the copper chimney surrounding the burner may fall on the sensitive paper attached to the registering apparatus. This consists of a stand supporting horizontally on friction rollers two concentric glass cylinders, round the inner of which is wrapped a sheet of prepared photographic paper: the outer or covering cylinder keeps the paper moist during the twenty-four hours it remains in action. A bent arm, attached to the axis of these cylinders, is carried round by a fork at the end of the hour-hand of a timepiece specially constructed for the purpose. The horizontal motion of the tracing point of light, combined with the vertical motion of the paper, traces out the magnetic curve. A third light is attached to the registering apparatus, for the purpose of drawing a standard or base line on the paper; by the varying distance of any point of the magnetic curve from this line, the magnetic variation is determined. At the distance at which these instruments are placed, an angle of 1° is represented by two inches on the paper; but the scale value may be enlarged at pleasure, by placing them further apart.

A A, the declination magnet.

B, a concave speculum attached to the magnet.

C, a plane glass mirror also attached to the magnet, for making observations by a telescope, on the old method, when required.

D, the torsion plate, reading to minutes by two verniers.

E, a frame standing upon the torsion plate. A hook, capable of being raised or lowered by a screw, is attached to this frame, from which the magnet is suspended by a skein of untwisted silk fibres.

F F F, a glass box, in which the magnet and its appendages are enclosed, to protect them from the air; for the same purpose, the suspension skein is enclosed in a glass tube G, which passes through a stuffing box H, in the lid of the box.

I, a gas-burner enclosed in a brass chimney, from which no light can escape, except a small pencil which passes through a narrow slit K, capable of being adjusted by a screw; on the breadth of this slit, the breadth of the register line depends.

L L, a combination of two plano-convex cylindrical lenses. The pencil of light passing through K, falls on the mirror B, and is reflected to the cylindrical lenses; by these, the image of the slit is condensed to a point of light on the surface of

M M, the registering apparatus, consisting of two concentric cylinders, between which the photographic paper is placed.

N, the magnetic curve traced by the point of light.

O, a gas-burner, fixed to the stand on which the cylinders rest.

P, a plano-convex prismatic lens, attached to the top of

Q Q, an opaque box, which protects the photographic paper from extraneous light. A pencil of light from O passes through P, and is brought to a focus on the surface of the paper.

R, the base line, described by the point of light.

S S, the bifilar, or horizontal force magnetometer.

T T, the apparatus for producing an automatic temperature compensation; this consists of two zinc tubes, which are clamped to a glass rod by two adjustible clamps V V, the suspension skein passes over a pulley X, and the ends are attached to two hooks W W; as the temperature rises, these hooks are approximated to each other by a quantity equal to the difference of the expansion of the glass rod and the zinc tubes, between the clamps V V; and thus the torsion force is diminished; the position of the clamps is so adjusted, that the diminution of the torsion force shall be equivalent to the loss of power in the magnet: and *vice versâ*, when the temperature falls. The magnet, its appendages, and the suspension skein are enclosed similarly to the declination magnet; the glass box, &c., is omitted to avoid confusion. The registration of its movements is likewise similarly effected on the opposite side of the cylinders.

A blackened zinc case is placed over the cylinders, when in actual operation, to prevent any light from falling on the paper, except the two pencils which describe the magnetic curves, and another which passes through a prism on the top of the case, and draws the base line. In order to avoid confusion this is omitted in the drawing, as well as another case of the same material, which covers the whole of the apparatus, to protect the sensitive paper from any stray light, as well as to defend the whole from dust, &c.

Fig. 2 represents the Balanced Magnetometer, the Barometer, and the apparatus on which the indications of both these instruments are registered.

A A, a self-registering barometer, enclosed in a case, resting on a stand.

B B, the upper and lower ends of a syphon barometer tube, which are of the same diameter, and of large size.

C, a float resting on the surface of the mercury, which hangs in a notch on the short arm of a lever.

D, the pivot on which the lever turns.

E, the long arm of the lever, which carries at its extremity an opaque screen F, with a small aperture, through which a small pencil of light passes.

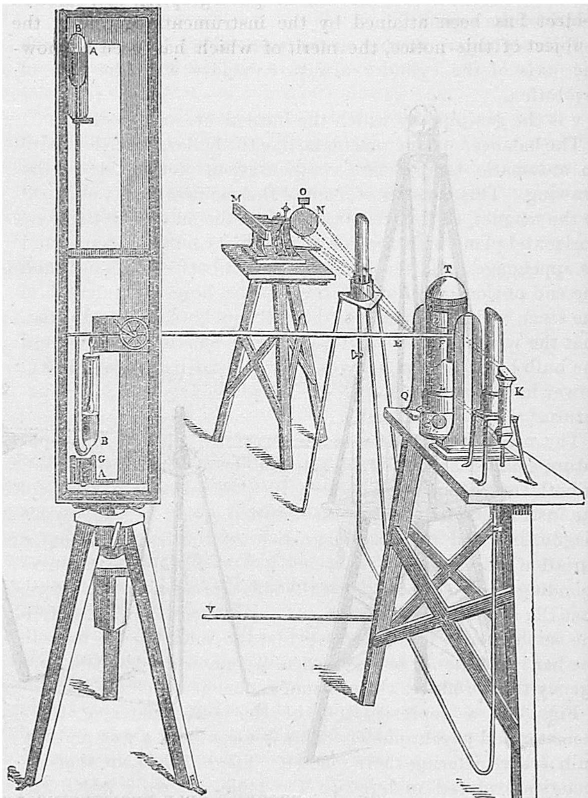

FIG. 2.—BROOKE'S SELF-REGISTERING BALANCED MAGNETOMETER, AND BAROMETER.

G, a plate on which the tube rests, which is raised or lowered by a screw.

H, a stand supporting a gas-burner.

I, the register line, described by the pencil of light transmitted by the screen F, which will evidently rise and fall with the column of mercury; the indications will be amplified in proportion to the length of leverage.

K, a tube with a plano-convex prismatic lens at each end of it, placed at the back of the burner; through this, a pencil of light is conducted in the direction indicated by the dotted line, and describes the base line L. By this arrangement, two pencils are derived from the same source of light, which fall perpendicularly on two remote points of the paper.

M, the Balanced Magnetometer, is supported by a brass framework surmounted by agate planes, and firmly attached to a slab of black marble, which, like the preceding instruments, would be cemented on the top of an insulated stone pillar, when in actual operation; it would also be enclosed in an air-tight case (omitted in the drawing), having a plate-glass window in front of

N, a concave speculum, connected with the magnet by a brass bar in which two agate knife edges are imbedded; these rest on the agate planes attached to the supporting frame. The knife edges may be raised out of gear on four Y's by means of an eccentric.

O is a small plane mirror for making observations with a telescope in the usual manner.

P, a gas-burner, similar to those of the preceding instruments. A small pencil of light proceeding from this is reflected from the speculum N towards the photographic apparatus, and passing through

Q, a combination of two plane convex cylindrical lenses in a frame of wood, falls upon a vertical revolving cylinder covered with photographic paper, and describes

R, the register line.

S, is a brass frame which supports a turn-table on three vertical and three horizontal rollers. A pin projects vertically from the centre of the turn-table, which enters a hole in the centre of the cap of

T, the cylinder, resting on the turn-table; by these means the axis of the cylinder always coincides with the axis of revolution.

V is the gas-pipe by which the burners are supplied.

The balanced magnetometer is, like the bifilar, furnished with an automatic temperature compensation, not visible in the drawing. This consists of a small thermometer tube, clamped to the magnet, so that the axis of the tube may be in the same horizontal plane with the centre of gravity of the magnet and its appendages, and the centre of motion between the bulb and the end of the thread of mercury in the bore. The length of the stem, and the capacity of the bulb and bore, are so adjusted, that the weight of the small quantity of mercury driven out of the bulb by expansion, may exactly counter-balance the loss of power in the bar occasioned by the same elevation of temperature.

The necessity of this and the previously described temperature compensation, will be better understood by stating that, in both the force magnetometers, the position of equilibrium of the instrument depends on the mutual action of the earth's magnetism and the free magnetism of the bar, and that a variation of either of these elements will induce a corresponding change of position of the magnet. In order, therefore, that the magnetic curve may truly represent the changes in the earth's force, it is necessary that the variations of force in the bar itself should be mechanically counteracted by the same agency that produces them, namely, change of temperature.

Fig. 3 is a representation of the self-registering thermometer and psychrometer. This is essentially a wet and dry bulb self-registering thermometer. The bulbs of the thermometers are placed underneath the table, through which the stems pass vertically, and are placed between the opposite sides of the cylinder sand two lights. A narrow vertical line of light, brought to a focus by a cylindrical lens, falls on the stem of the thermometer, and passing through the empty portion of the bore, affects the prepared paper. The boundary between the darkened and undarkened portions indicates the position of the mercury in the stem of the thermometer. Fine wires are placed across the slit in the frame through which the light falls on the stem; and coarser wires at every 10th degree as well as at certain other fixed points of the scale, namely, 32°, 54°, 76°, and 98°. The shadows of these wires protect the portions of the photographic paper on which they fall from the action of light, and the darkened surface of the paper is consequently traversed by a series of parallel pale lines; and the relative position of the broad and narrow lines readily explain the temperature indicated by the register. In this illustration figures are used instead of letters:—1, 2, are camphine lamps,—now superseded by gas, whereby the time and labour of trimming, and a greater uniformity of light has been obtained;—3, 4, are cylindrical lenses, by which a bright focal hue of light has been obtained; 5, the psychrometer or wet bulb thermometer; 6, the dry bulb thermometer; 7, two concentric cylinders, between which the photographic paper is placed; 8, the register, as it appears after the impression is developed; 9, one of the rollers of a turn-table, on which the cylinders rest; 10, the frame which contains the timepiece; 11, a bent pin, or carrier, attached to the axis of the cylinder, this is carried round by a fork at the end of the hour-hand of the timepiece.

As this apparatus is necessarily placed in the open air, when in actual operation, it is provided with an inner cylindrical zinc case, with sliding doors, to protect the sensitive paper from light, when the cylinder is removed from, and brought back to, the photographic room; and an outer wind and water-tight zinc case, with water-tight doors, for removing and replacing the cylinders, and for trimming the lamps, if lamps are used.

As the time pieces employed in notating the photographic cylinders exhibit several peculiarities of construction, our account of the apparatus would be incomplete without some mention of them. In order to avoid the unsteadiness of the hour-hand, which in ordinary movements results from the play of the motion-wheels under the dial, the central axis which carries the hour-hand is in the train, and the axis which carries the minute-hand is placed out of the centre. As the forked or carrying arm is firmly attached to the axis, another moveable hand or pointer is added, which travels with the former, and points to the hour. The compensating-bars of

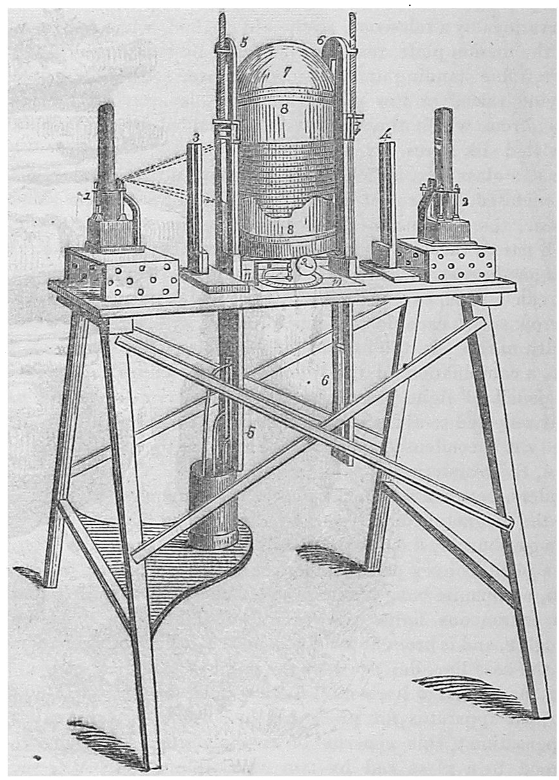

FIG. 3.—BROOKE'S SELF-REGISTERING THERMOMETER AND PSYCHROMETER.

the balance of this piece are composed of brass and palladium, to prevent the rate being influenced by proximity to the magnets. The numbers of the leaves in the pinions are all prime to the numbers of the teeth in the wheels with which they are in gear, to diminish the chance of irregular motion from wear, as the face of the piece must necessarily be exposed.

A lithographic fac-simile of one day's work of all the photographic self-registering instruments employed at the Royal Observatory, Greenwich, will be found in the introduction to the volume of "Greenwich Magnetical and Meteorological Observations for 1847," to which the reader is referred for further information respecting the practical application of the apparatus, as well as for a more detailed description of it. The reader is also referred to a series of papers by the inventor, published in the "Philosophical Transactions."